

## **REMARKS**

Claims 1 and 6 were rejected as unpatentable over Smith in view of Marko. Claims 3 and 4 were rejected as unpatentable over Smith in view of Marko in further view of Carlson. Claim 5 was rejected as unpatentable over Smith in view of Marko in further view of Kim. Claim 7 was rejected as unpatentable over Smith in view of Marko in further view of Rattlingourd. Claim 8 was rejected as unpatentable over Smith in view of Marko in further view of Rattlingourd in further view of Kim in further view of Tucci. Applicant requests reconsideration. The claims were restated for clarity.

Applicant extends appreciation for the thorough examination. The cited references describe improvements in early-and-late gate timing recovery. There are major differences between the early-and-late gate approach of the cited references and the claimed random walk filter. The early-and-late gate approach essentially detects the times of ascending crossing and descending crossing of a threshold level. This is well-known threshold detection. By noting the time differences between the estimated time at the center of the pulse and the early and late times of threshold crossing, the estimated time of pulse center is adjusted. The random walk filter, on the other hand, counts the number of times over many data periods that the baseband waveform pulses that are obtained by differentiating the baseband waveform, lead or lag the corresponding delayed or adjusted reference timing pulses.

1       The random walk filter does not determine the amount of lead  
2 or lag for each pair of pulses that could be had by simple  
3 threshold detection, as in the cited references. The random walk  
4 filter sums, over many data periods, accumulative +1's, as a the  
5 total count for leads of any amount and -1's for lags of any  
6 amount, for indicating whether any adjustment to the reference  
7 timing pulse delay is needed, for improved synchronization with the  
8 baseband waveform. When the delayed reference timing pulses are  
9 synchronized with the baseband waveform, +1, -1 and 0 would be  
10 randomly distributed over the many data periods, with the total  
11 count resembling the Brownian motion, thus resulting in the name of  
12 random walk filter approach to timing recovery. This is the major  
13 difference between early-and-late gating and random walk filtering.  
14

15       The examination states that Smith does not disclose a  
16 threshold comparator and a timinge pulse delay adjustor, but that  
17 Marko disclose a threshold comparator and a timing pulse delay  
18 adjustor. This combination does not reach the claimed invention.  
19

20       The random walk filter has a timing window that initially  
21 covers an entire data period, so that the random walk filter can  
22 always find the baseband waveform pulse corresponding to a  
23 particular adjusted reference timing pulse. The window can decrease  
24 to very small size as the baseband waveform is acquired and  
25 tracked. By contradistinction, the early-and-late gate window is  
26 centered at the pulse center and will always register each and  
27 every early and late crossings of the threshold. Depending on the

1 threshold level relative to the peak value, the window cannot be  
2 decreased below a specific size.

3

4       Thresholding has different meanings between the early and late  
5 gate and the random walk filter. The threshold for the early-and-  
6 late gate determines the time, relative to the pulse center, for  
7 the crossings. By contradistinction, the random walk filter uses  
8 two thresholds, the first threshold allows the count to be reset  
9 and the second threshold is set so that any count below that  
10 threshold would not result in any adjustment to the delay. This  
11 ensures that the random walk filter would not make adjustments  
12 based on noise. Thus, threshold for the early-and-late gate  
13 approach is an amplitude detection threshold while the two  
14 thresholds for the random walk filter approach are counting  
15 thresholds.

16

17       While the random walk filter may include conventional  
18 components as in the cited references, the random walk filter  
19 provides a fundamentally different approach to timing recovery. The  
20 random walk filter implements accumulative lead and lag counting  
21 over many data bits to achieve timing recovery, whereas the cited  
22 references use conventional localized threshold detection for  
23 timing about a pulse center. The cited references do not teach nor  
24 suggest accumulative lead and lag counting using random walk  
25 filtering over a large time period.

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27       It is true that the reference timing pulses are locally  
28 generated. However, the adjusted timing pulses are corrected by the

1 random walk filter so that the adjusted timing pulses are  
2 synchronized with the baseband waveform for accurate bit detection.  
3

4 The timing pulse delay adjuster (26) does not delay the adjusted  
5 timing pulses. It delays the reference timing pulses to produce the  
6 adjusted timing pulses to be synchronized with the baseband  
7 waveform.

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9 Smith proposed a technique based on early-and-late gate phase  
10 comparator and reversible binary counter.

11  
12 Marko also proposed an early-and-late gate technique using two  
13 digital phase lock loops with narrowband and wideband filters.  
14 These versions of the early-and-late gating are different to the  
15 random walk filter approach in several aspects.

16  
17 Carlson also used the early-and-late gate technique by setting  
18 the early and late windows and detecting the timing data relative  
19 to the window centers. Again, while using some of the same  
20 components, this early-and-late gate approach is quite different  
21 than the random walk filter approach.

22  
23 Kim used a training sequence with a predetermined pattern to  
24 synchronize incoming waveform with clock periods. Lead or lag  
25 information is then used for clock adjustment. This is a technique  
26 for acquisition before data waveform is received while the random  
27 walk filter approach performs timing recovery while processing data  
28 waveform.

1           Rattlingourd used an Oscillator to generate a signal at a fixed  
2 frequency ( $f$ ), which is much larger than the data rate. Through a  
3 Variable Divider with value  $m$  (e.g., 200), a clock output signal is  
4 produced with rate  $f/m$  that is close to the data rate. A Phase  
5 Detector is then used to detect differences between the positive  
6 going and negative going edges of the data and the clocking edges  
7 of the clock signal. Its output drives an Up/Down Counter. A Window  
8 Counter also compares data edges with the clocking edges to assess  
9 the scope of the timing error. The outputs of the Up/Down Counter  
10 and Window Counter modify the value  $m$  of the Variable Divider. If  
11 there is no difference between data edges and clocking edges, the  
12 value  $m$  remains the same. When there is a difference,  $m$  would  
13 increase or decrease. Increasing  $m$  by unity essentially delays the  
14 arrival of the next clocking edge by one oscillator cycle, and the  
15 next clocking edge after that by 2 oscillator cycles, and so forth.  
16 Decreasing  $m$  has the opposite effect. The clock output signal rate  
17 is also affected by a change in the value  $m$ . The random walk filter  
18 approach, on the other hand, provides a time delay that shifts all  
19 the timing pulses. The delay is adjusted through by the output of  
20 the random walk filter. Thus, there are four differences between  
21 the approaches. Rattlingourd's technique adjusts the quantity  $f/m$ ,  
22 which is the estimated data rate, while the random walk filter  
23 adjusts delay. Rattlingourd's oscillator generates a frequency much  
24 higher than the data rate, while random walk filter generates  
25 timing pulses at the data rate. Rattlingourd's approach requires  
26 that the timing comparison between data edges and clocking edges  
27 occurs at the clocking edges of the clock signal. The random walk  
28

1 filter allows the counting of a data transition pulse within a  
2 large window, of the order of a data period, centered at the  
3 corresponding timing pulse. Rattlingourd's approach requires the  
4 adjustment of the parameter m to occur at the edges of the clock  
5 signal, while in random walk filter, the delay can be adjusted at  
6 any time. Rattingourd describes leads and lag with up and down  
7 counting and adjusts recovery timing by changing pulse separation,  
8 whereas, the random walk filter recovery loop adjust the timing  
9 pulse delay delaying the data stream with equal and fixed bit  
10 separation. Rattingourd does not suggest and teaches contrary to  
11 equal and fixed bit separation using an adjusted timing pulse  
12 delay.

13

14 Tucci used a bank of delay lines to capture the lead and lag  
15 signals, a phase locked loop to track the timing error, and a phase  
16 comparator to make adjustment. This approach is much like the  
17 early-and-late gate technique in that it estimates the amount of  
18 lead and lag, and adjusts accordingly. Therefore, while using some  
19 of the same components, this approach is quite different than the  
20 random walk filter approach.

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1       The cited references teach early-and-late gating using  
2 threshold detection over a data period for timing recovery. The  
3 random walk filter using clock counting over many time periods to  
4 shift the adjusted timing pulses. The invention proceeds contrary  
5 to the cited references and cited reference are thus strong  
6 evidence of non-obviousness. Allowance of the claims is requested.

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10     Respectfully Submitted

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